

## Handling capacity bottlenecks in digital networks

The invention relates to a method of handling capacity bottlenecks in digital networks, particularly digital home networks, in which at least two appliances or applications with public interfaces for influencing the internal resource allocation in a system have access to the resources of a data transfer medium having a non-constant bandwidth.

5 Information is processed with an increasing digitization and linking of processing media. In so far as the home range is concerned, the associated networks are referred to as digital home networks (IHDN: in-home digital network). Televisions, radio, monitors, loudspeakers, cameras, printers, scanners, PCs, telephone services, speech recognition systems, home appliance controls, security devices and the like may be integrated  
10 in such an IHDN. Particularly in the audio and video media with their high data transfer rates of up to 100 mbit/s, conflicts of use often occur when different applications compete for resources (both apparatus and network resources).

This effect is even stronger when the bandwidth of the data transfer medium is changed, for example, because of external influences. Users of CE appliances expect a high  
15 quality of the observed pictures and sounds. The arrangement of digital multimedia data at home may be either cabled or wireless. Some cabled as well as all uncabled transmission types cannot, however, give any guarantee about the available bandwidth because they share the transmission medium (cable, air) physically with uncontrolled appliances (vacuum cleaners, microwaves, Bluetooth devices). This lack of bandwidth guarantee may cause to the  
20 fact that the available bandwidth falls below the bandwidth required by multimedia streams in operation. This means that, for some streams, fewer data can be transmitted than is required for the representation in optimal quality. Such capacity bottlenecks require a prioritisation of data streams, on the basis those necessary data streams reductions will be carried out, where required.

25 Prioritisation of data streams in dependence upon the type of transported information (for example e-mail vs. web vs. video) has been known for a long time, as well as the prioritisation by means of a simple description of the requirements of a data stream (for example, the TOS bits in IP). This method is, however, unsuitable for prioritisation of data

streams of the same type (such as, for example, video and audio) occurring typically in digital home networks.

Traffic shaping and control algorithms allow the prioritisation of their queues (for example, the CBQ, HTB and PRIO disciplines of Linux traffic control mechanisms).

- 5 This method is particularly suitable for implementing stream priorities, but not for fixing them.

Several methods are proposed for data stream transmission on the Internet, using prioritisation. In the method of the standardized "Differentiated Services", different service classes are allocated to data packets and obtain resources in conformity with these  
10 classes. Different classes may have different priorities. It is, however, not specified in accordance with which criteria classes are allocated to packets. Furthermore there is only a statistically predefined number of classes.

All of these systems use either priorities predetermined by applications or even fixed priority classes.

- 15 In virtual reality environments, decisions as to what elements in the environment must be represented are made on the basis of the virtual location and the virtual direction of view of the user. Analogously, in virtual reality video conference systems, decisions about the indicated streams of conference participants are made. This method is used for continuous regulation of stream qualities and is thus not suitable for hiding  
20 deviations from the maximum quality as much as possible.

It is therefore an object of the invention to provide a method which makes it possible to substantially hide quality adaptations of the data streams from the user, which quality adaptations are required due to capacity fluctuations in digital networks having a non-constant bandwidth. According to the invention, this object is achieved in that, in the case of  
25 a resource bottleneck, the data transfer rate of that data stream is reduced whose effect on the associated application is least observed by the user.

The proposed method is used for handling capacity bottlenecks in digital networks, particularly digital home networks, in which at least two appliances or applications with public interfaces for influencing the internal resource allocation in a system have access  
30 to the resources of a data transfer medium having a non-constant bandwidth. Such capacity bottlenecks particularly occur when systems without bandwidth guarantee, particularly wireless systems, are affected by external influences such as, for example, domestic appliances. Within the scope of the method, the participating applications are given priorities on the basis of their user-subjective quality requirements, wherein the data stream whose

allocated application probably has the lowest quality requirements from the user's point of view is the first to be reduced. In this connection, inter alia, the following relations are utilized:

- 5       - streams to which little or no attention is paid such as, for example, a television which is operative in the kitchen during cooking may be reduced in quality without the user noticing this as a disturbance.
- recorded streams have the potential of being viewed multiple times. During their recording, they have thus greater importance as streams that are viewed live, whereas they have lesser importance during playback.
- 10       - streams viewed/listened to by a plurality of persons have a greater importance than those viewed by only one person, particularly when the other persons are guests.
- there are broadcasts and programs which are less important to the user or in which parts are considered to be less important such as, for example, the video information given on music stations.
- 15       - at different hours, the streams of different users may have priority, for example, streams for children in the afternoon and streams for parents in the evening.
- different sources or end appliances raise different user expectations concerning the grade of interference. Disturbances regarding transmissions from the Internet or a mobile appliance will be sooner condoned than those from the television in the living
- 20       room.

      In the case of an occurring lack of resources, the streams having the lowest priority are the first to be reduced in quality or aborted completely. As a result, the user does not notice the required quality reduction or experiences it as a less disturbing phenomenon. This leads to a subjectively higher quality level.

- 25       In a further embodiment of the invention, for selecting the data stream to be reduced, a priority for each stream is regularly determined by the users from information on the context and from the contents of all streams, and the different applications/operating system components are notified about this determined priority for each stream. This ensures that the applications can react without delay in the case of a resource bottleneck.

- 30       According to the invention, the applications in the system transmit their quality requirements in combination with their connection requirements. This ensures that the minimal requirements of the appliances or applications are taken into account when computing the priorities. Consequently, reject factors such as, for example, burning failures on a CD because of a data stream break-off are avoided.

In an advantageous embodiment of the invention, the user is enabled to deny a quality limitation of the system, whereupon the system determines the next best priority and notifies the applications about it. This enables the user to act, so that a subjective quality, which the user experiences as a negative quality, can be counteracted.

5           Advantageously, user denials are stored by the system and taken into account when determining future priority computations. Consequently, the system acquires a learning capability so that its practical usefulness is enhanced. The efficiency of the system is continuously improved by the permanent adaptation of the computations to the quality experienced by the user as a real quality.

10           Further embodiments of the invention are defined in the dependent claims. These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

In the drawing:

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Fig. 1 shows diagrammatically the method according to the invention.

In a digital home network (IHDN), as shown by way of example in Fig. 1, different applications 1a, 1b, 1c compete for resources. The example relates to a radio  
20 network in accordance with the IEEE 802.11b standard. The network includes, for example, a television set 1a (in the kitchen), a computer 1b as well as hi-fi equipment 1c. The applications 1a, 1b, 1c receive their data streams from a home archive 2. A network 5 supporting Quality of Service (QoS), particularly priority-based QoS, is present between the home archive 2 and the applications 1a, 1b, 1c. For a radio network in accordance with IEEE  
25 802.11b, this is substantially a support of the priority classes of IEEE 802.11e. However, analogously, IEEE 802.15.3 or home plug 1 may be used. When the network itself does not provide QoS, the exceptional case arises that the applications themselves must implement QoS.

The applications 1a, 1b, 1c require their necessary data streams from the QoS  
30 prioritizer 3; co-transmitting their QoS requirements. When legacy applications are concerned, which have direct access to the network 5 without considering the prioritizer 3, the corresponding accesses are either communicated to the prioritizer 3 by the network 5 or detected by the prioritizer itself when it monitors the network traffic. The requirements that are

lacking in these cases are substituted for default values which are dependent on possibly detected applications or the type of stream.

The prioritizer 3 now checks, possibly on the basis of the application requirements 4, whether the required stream leads to a structural overload of the available network resources. In this case, it denies the requirement. In the opposite case, the prioritizer enriches the requirement 4 with information about the content of the stream (content metadata) 9, about the present wishes of the user and his current environment and about his actions 8. He receives this information from further components such as the home archive 2, the user data base 6 and the context detector 7 which are parts of the system. However, principally, external sources may also be concerned. The requirement data thus enriched of the new stream are combined with the enriched requirement data of already existing streams and checked on the existence of particular situations (such as the situations described above). On this basis, a priority is determined for the new stream and the priorities 10 of existing streams are possibly changed. The new and changed priorities 10 are then communicated to the network 5 or the applications 1a, 1b, 1c in a corresponding format – in the example as priority classes in accordance with IEEE 802.1d. When they are communicated to the applications which do not implement QoS themselves, these applications pass on the priorities 10 to the network 5.

For example, the prioritizer 3 will allocate a lower priority 10 to the video data stream to the television set 1a in the kitchen, because it has been assumed that the user will observe the corresponding broadcast mainly acoustically and will hardly watch it. If, in contrast, a CD recorder integrated in the hi-fi equipment 1c has required a stream from the home archive 2 or from PC 1b, the prioritizer 3 will allocate a high priority 10 to this stream, because an interruption of the stream may lead to uselessness of the written CD.

When the newly required stream is a stream having a scalable bandwidth, the prioritizer 3 does not determine a priority for the stream but a priority for each of its transmission bands.

The current data flow 51 is actually transmitted under the sole responsibility of the network 5. When resource bottlenecks occur, the QoS-capable network 5 automatically reduces the bandwidth occupied by the less important streams by transmitting packets of these streams only partially or with a delay, or by not transmitting them. When the applications 1a, 1b, 1c implement QoS themselves, this reduction applies to them. When the user observes the reduction of quality contradictorily to the prognosis of the system and experiences it as a disturbance, he communicates this to the system via a user interface 11 of

the television set 1a. This information of user denial is forwarded to the QoS prioritizer 3 which computes an alternative priority 10, communicates it to the applications 1a, 1b, 1c and adapts the data streams accordingly. The user denial is stored for the computation of future priorities by the QoS prioritizer 3.

5                   The prioritizer 3 is informed about changes of the priority decisions, influencing data 52 e. g. about the current situation of the user or about the content of the stream, but also about longer lasting bandwidth limitations of the network 5 and thereupon possibly changes the priorities 10 of already existing streams and informs the network 5 or the applications 1a, 1b, 1c about this.

10                   When, in the above example, the context detector 7 determines that the "kitchen work" - status no longer applies to the user who is in the kitchen (for example, because all kitchen appliances have been switched off or because the user permanently looks in the direction of the television set), he the prioritizer 3 about this change in state, which thereupon, under circumstances, increases the priority of the stream to the television set 1a.

## LIST OF REFERENCE SIGNS

|    |        |                                      |
|----|--------|--------------------------------------|
|    | 1a,b,c | applications                         |
|    | 2      | home archive                         |
|    | 3      | Quality of Service (QoS) prioritizer |
|    | 4      | application requirements             |
| 5  | 5      | QoS network                          |
|    | 6      | user data base                       |
|    | 7      | context detector                     |
|    | 8      | context and user information         |
|    | 9      | content metadata of the data stream  |
| 10 | 10     | network priority                     |
|    | 11     | user interface                       |
|    | 51     | current data flow                    |
|    | 52     | control data flow                    |